OPTIMIZING MUSCLE PARAMETERS IN MUSCULOSKELETAL MODELING USING MONTE CARLO SIMULATIONS

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Astronauts assigned to long-duration missions experience bone and muscle atrophy in the lower limbs. The use of musculoskeletal simulation software has become a useful tool for modeling joint and muscle forces during human activity in reduced gravity as access to direct experimentation is limited. Knowledge of muscle and joint loads can better inform the design of exercise protocols and exercise countermeasure equipment. In this study, the LifeModeler™ (San Clemente, CA) biomechanics simulation software was used to model a squat exercise. The initial model using default parameters yielded physiologically reasonable hip-joint forces. However, no activation was predicted in some large muscles such as rectus femoris, which have been shown to be active in 1-g performance of the activity. Parametric testing was conducted using Monte Carlo methods and combinatorial reduction to find a muscle parameter set that more closely matched physiologically observed activation patterns during the squat exercise. Peak hip joint force using the default parameters was 2.96 times body weight (BW) and increased to 3.21 BW in an optimized, feature-selected test case. The rectus femoris was predicted to peak at 60.1% activation following muscle recruitment optimization, compared to 19.2% activation with default parameters. These results indicate the critical role that muscle parameters play in joint force estimation and the need for exploration of the solution space to achieve physiologically realistic muscle activation.